

Climate Induced Changes in Biogenic Emissions: Global Chemical Effects

Cynthia Atherton, Daniel Bergmann, Jane Dignon, Keith Grant, John Tannahill

December 8, 2003

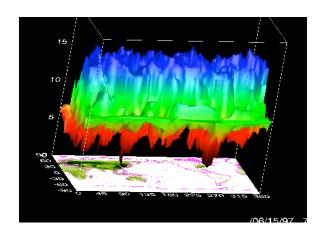
American Geophysical Union San Francisco, CA, United States December 8, 2003 through December 12, 2003

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Climate Induced Changes in Biogenic Emissions: Global Chemical Effects



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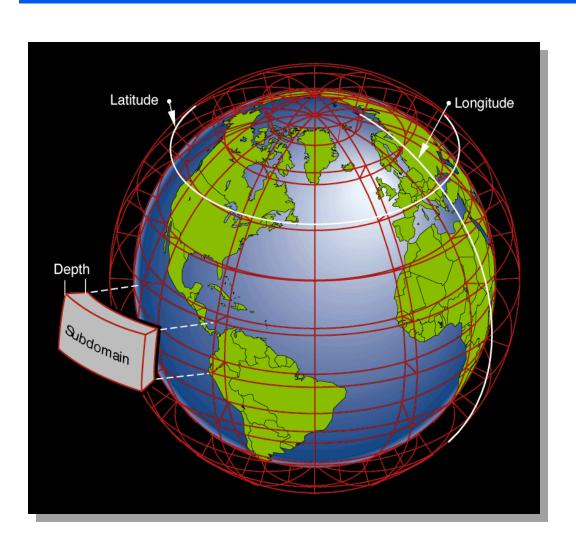
Atmospheric Chemistry Group Atmospheric Science Division Lawrence Livermore National Laboratory Livermore, CA 94550

atherton2@llnl.gov December 9, 2003

This work was performed under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

Use global, 3D model, <u>IMPACT</u>: How do 1 and 4K temp. increases affect biogenic emissions [] products?





- Processes: Chemistry, photolysis, advection, diffusion, wet & dry deposition
- Species: CO, CH₄, NO, NO₂, OH, O₃, C₅H₈, NMHCs, PAN, HNO₃, C_xH_y, BrO, CIO, (etc...to ~ 100)
- Meteorology:

MACCM3

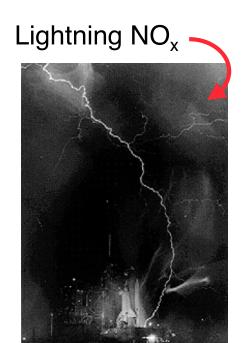
NASA/DAO (assimilated)

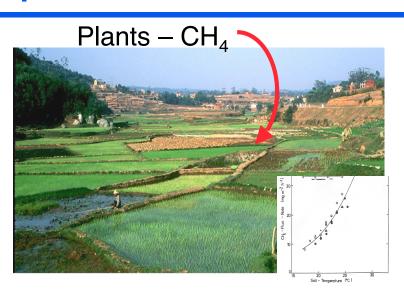
Resolution:

Met. Driven (2°x2.5°; 4°x5°; 1°x1°)

Emission rates of biogenic species (NO_x , CH_4 , C_5H_8) are *nonlinear* in temperature:









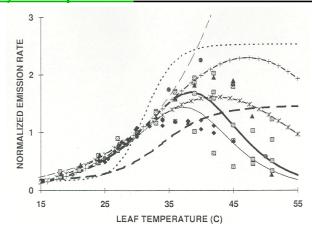


Affects many other species (e.g. O₃, OH, NO_x, HNO₃, PAN, ...)

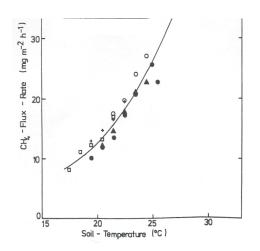
How will changes in <u>four biogenic emissions</u> affect atmospheric composition for T+1K, T+4K:



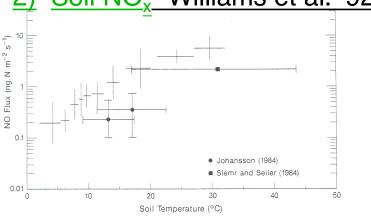
1) Isoprene - Guenther et al. 1993



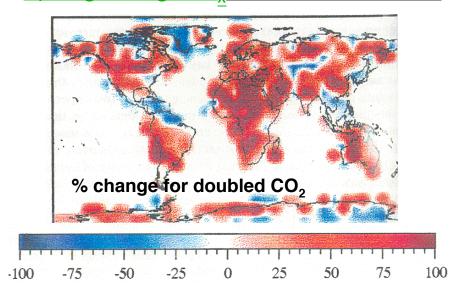
3) Soil CH₄ – Schutz et al. 89



2) Soil NO_x- Williams et al. '92



4) Lightning NO_x - Price & Rind '94



Temperature increases affect (1) biogenic emissions and (2) chemical reaction rates:



1) Biogenic emis. = fcn(T)

Soil
$$NO_x = A \square exp\{0.071\square T_{soil}\}$$

2) Reaction rate = fcn(T)

$$A + B \rightarrow products$$

$$k = A \square exp(-E_a/T)$$

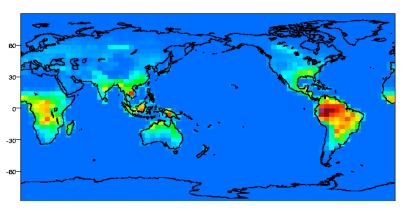
$$PAN \rightarrow CH_3CO_3 + NO_2$$

k \square A \square exp(-14000/T)

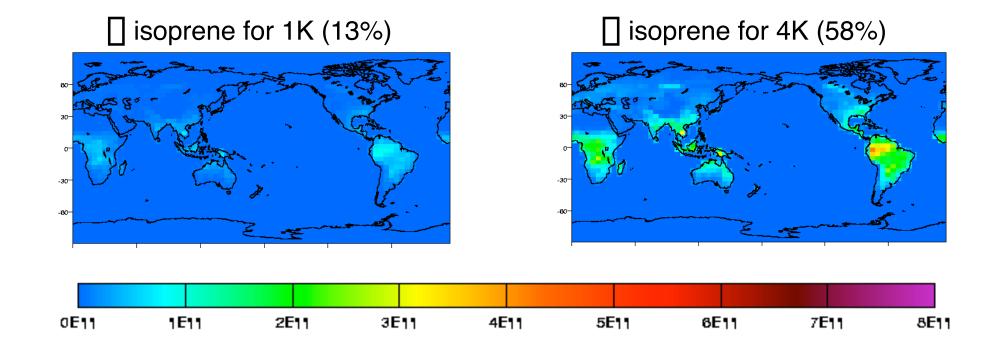
Scenario	Biogenic emissions	Reaction rates
Base	base	base
T + 1	7	7
T + 4K	7	7
T + 4K	7	
T + 4K		7

Isoprene emissions will increase as temperature ↑:



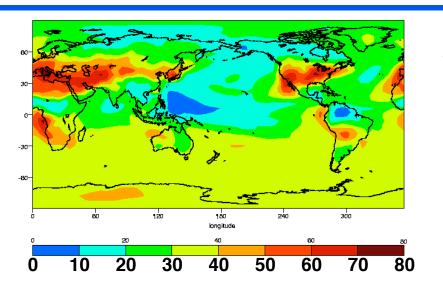


Present day (Base case) Isoprene source: #/cm²-s

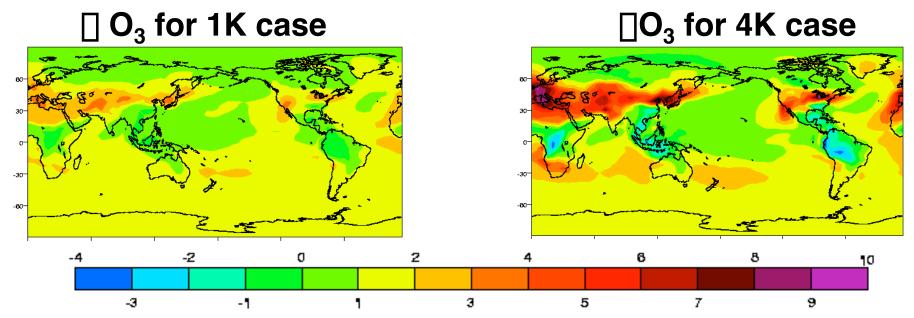


July Surface O₃ changes more for 4K than 1K:



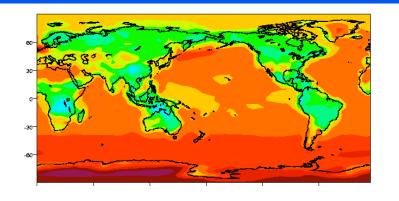


Surface O_3 , ppbv Base case

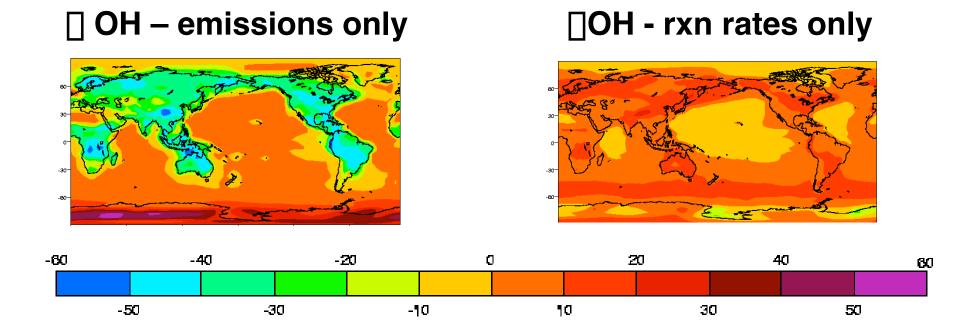


July surface OH for 4K case – Net decrease (land) mainly due to increased emissions



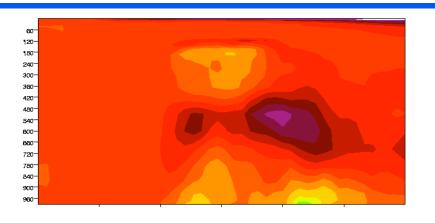


☐Surface OH in % T + 4K

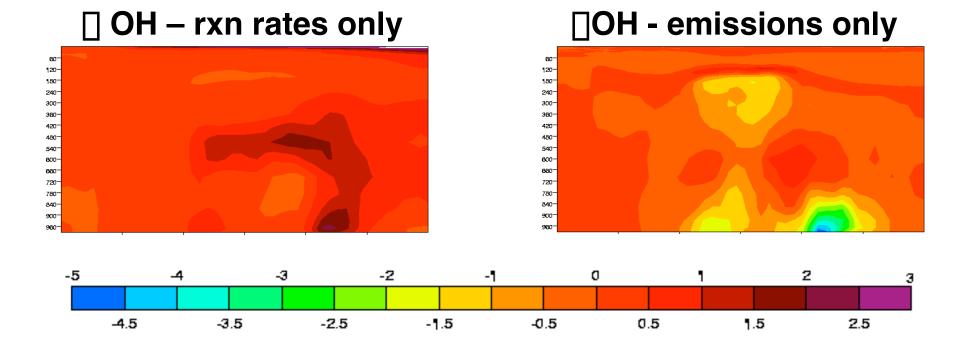


July zonal OH for T + 4K: Increase at 400-700mb Decrease at surface, Decrease above 400mb



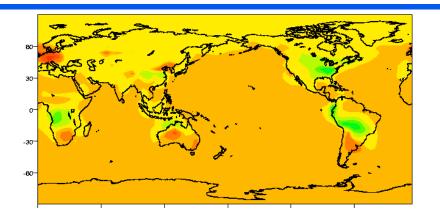


□OH, #/cm³ x 10⁻⁵ T + 4K

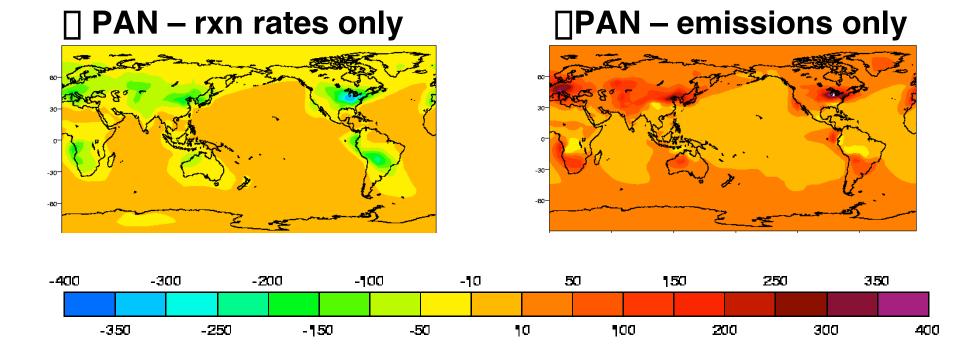


July surface PAN changes for 4K case - Net decrease due to reaction rates changing



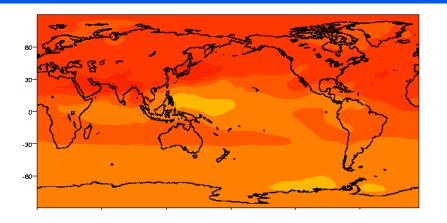


☐Surface PAN, pptv T + 4K

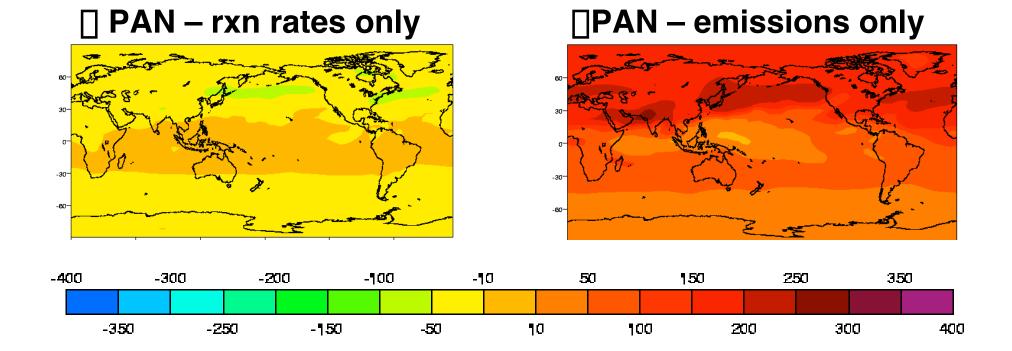


July 300mb PAN changes for 4K case - Net increase due to emission rates changing





□PAN at 300mb, pptv T + 4K



IMPACT model temperature increase of 1 - 4K affects (1) Biogenic emissions (C₅H₈, NO_x, CH₄) and (2) Reaction rates

- July Surface O₃ changes:
 - -4 to 10 ppbv for 4K
 - -2 to 4 ppbv for 1K
- July OH changes for 4K:

Decreases surface (\sim 50%), 200 – 400 mb Increases 400 – 700 mb

PAN depends on altitude for 4K

Surface: Net decrease

300 mb: Net increase

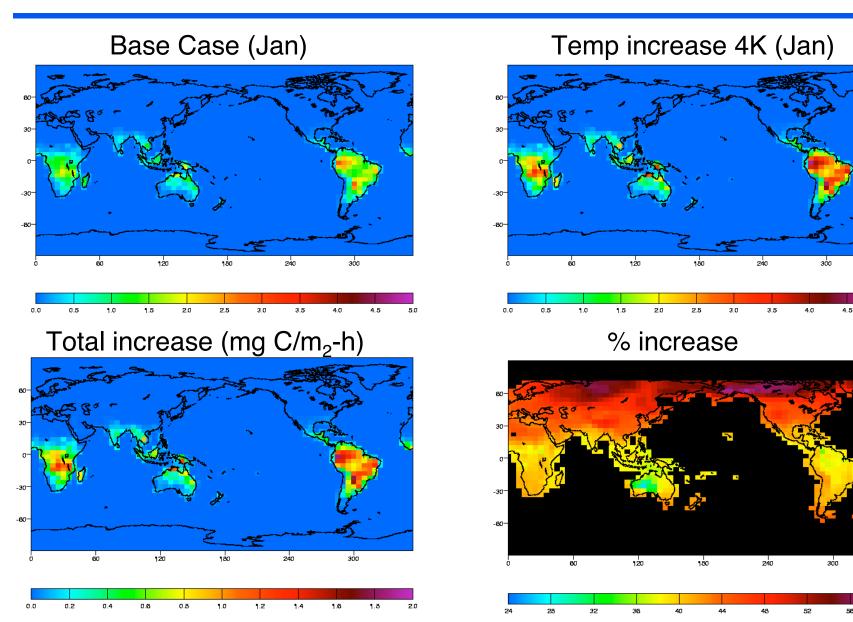
Future work includes different temperature representation (spatial, temporal)

Backup Slides follow...



Isoprene emissions will increase as temp ↑

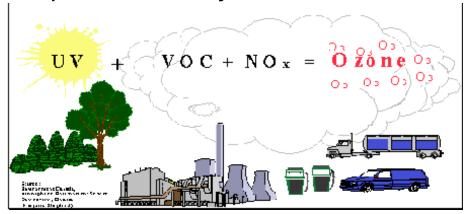




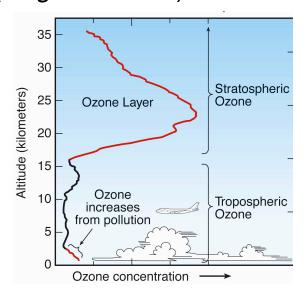
A key species is tropospheric ozone. It has two main "sources".



(1) Tropospheric in-situ photochemistry



(2) Transport from stratosphere (Huge reservoir)



Anthropogenic and natural forcing of the climate for the year 2000, relative to 1750

Global mean radiative forcing (Wm²)

Greenhouse gases

Aerosols + clouds

Black
Carbon
from
from
flossi
fuel

Dust
Copanic
Carbon
Contrats Cirrus

Solar
Corponic
Cerbon
flowing
Flossi
fuel
burning

Land use
(abbdo cirly)

The height of a bar indicates a best estimate of the forcing, and the
accompanying vertical ine at 84y range of values. Where no bar as present
indirect
effect

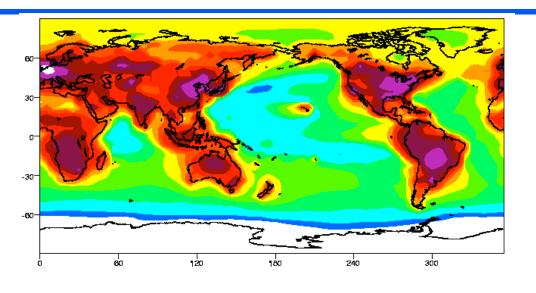
EVEL OF SUPPRINCIPATE

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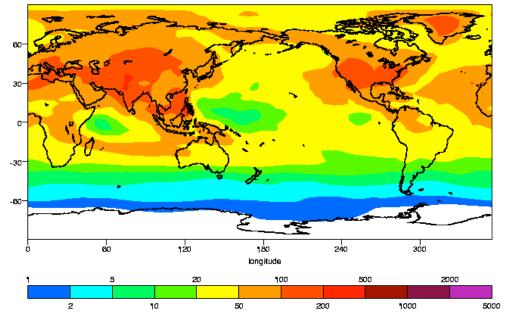
It can act as a greenhouse gas.

July NO_x for base case:





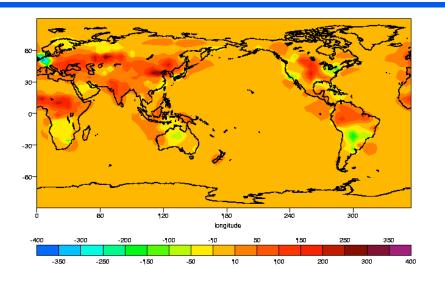
Surface NO_x, pptv Base case



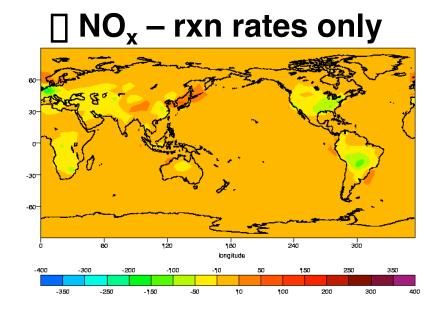
NO_x at 300 mb, pptv Base case

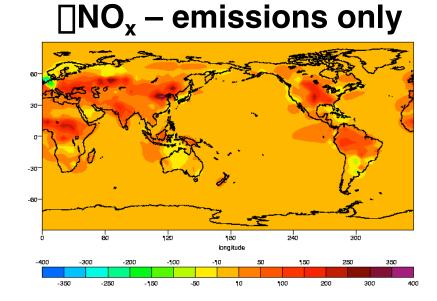
July surface NO_x changes for 4K case





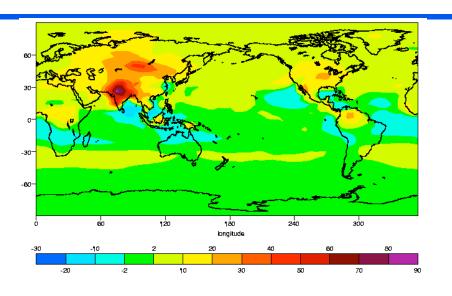
☐Surface NO_x, pptv T + 4K





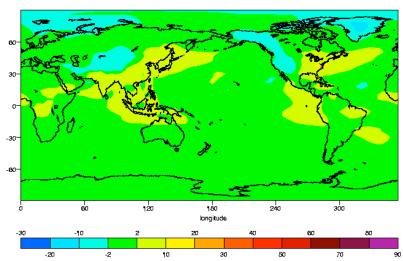
July NO_x changes at 300 mb for 4K case



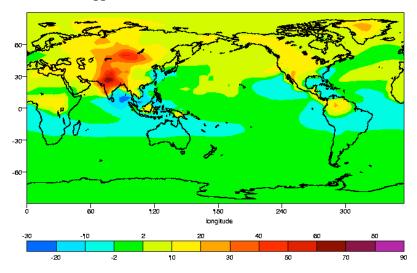


 $\square NO_x$ at 300 mb, pptv T + 4K



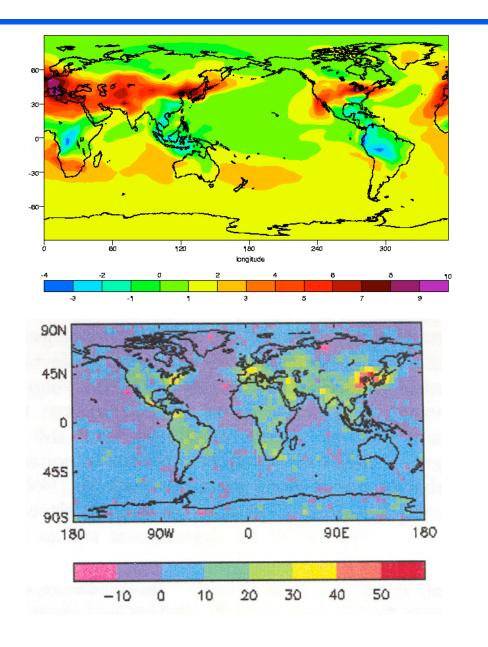


$\square NO_x$ – emissions only



Our surface O_3 changes are less than Sanderson et al. They also increased VOCs and NO_x (anthropogenic)





 $\square O_3$ at surf, this work $\Gamma + 4K$

 $\square O_3$ at surf, this work Sanderson et al., 2003 (Fig. 2, 2090-1990, Fixed vegetation)

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